Double-Crested Cormorant Culling in the St. Lawrence River Estuary: Results of a 5-Year Program

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Abstract: Modeling indicated that lowering the double-crested cormorant population from 17,361 to 10,000 pairs could be attained only by a combination of techniques: culling breeding birds in arboreal colonies to lower breeding stock and egg spraying in accessible ground nests to lower recruitment. The 5-year program was launched in 1989; culling was halted 4 years later because the population had fallen below the threshold of 10,000 breeding pairs. A greater vulnerability of males to shooting (203:100) probably accounted for the faster-than-predicted drop in numbers. Egg spraying spanned the entire 5-year period, during which 25,095 nests were treated with inert mineral oil. As predicted by the model, spraying lowered recruitment, but only after a 2-year lag. Culling should be considered a last-resort form of intervention whenever softer techniques (egg spraying, mechanical nest destruction, and carefully planned disturbances to the nesting colonies to enhance predation and abandonment) are not sufficient or practical to produce population control. Population control should be based upon careful planning (including detailed censuses, population modeling, and prior communication with the public) and be conducted under close scientific supervision.

Keywords: culling, double-crested cormorant, egg spraying, overabundance, *Phalacrocorax auritus,* population control, St. Lawrence River estuary

The St. Lawrence River estuary population of double-crested cormorants (DCCO's) grew from 6,155 breeding pairs in 1979 to 14,662 in 1987 and was predicted to reach 27,000 pairs in 1993. A population control program was introduced by the Québec Provincial government, mostly in response to growing concern about damage to unique island plant and animal communities and incidental destruction of nesting habitat for several aquatic species such as black-crowned night-herons (BCNH's, *Nycticorax nycticorax)* and common eiders *(Somateria mollissima).* More extensive rationale for adopting the culling[1] program has been outlined in Bédard et al. (1995a). The fishing (sport and/or commercial) lobby was not involved in the decision. The DCCO has not been labeled as a pest in Québec, and this program was aimed at only one of several populations. Birds nesting on the lower north shore, Anticosti Island, Gaspé/Baie-des-Chaleurs, and Magdalen Islands (see Chapdelaine and Bédard 1995 for the size and distribution of these populations) were not included in the program.

Deterministic modeling revealed that it would be impossible to halt growth, let alone reduce population size to the desired level of 10,000 pairs, with the softer (and cheaper) technique of controlling recruitment by egg spraying in accessible ground nests. Modeling confirmed that reducing the population to the desired level would also require culling 2,000 breeding birds in tree nests (inaccessible to egg spraying) during each year of a 5-year program. The sheer demographic weight of the tree nesting component would have sustained estuarine population growth even if recruitment in ground nests was reduced to zero. Initially scheduled to start in 1988, the 5-year program actually ran from 1989 through 1993. This study reports on the program's success following completion.

Study Area

The program was directed at all colonies (between 28 and 34 according to year) located between Montmagny and Baie-Comeau, a 300-km stretch of the estuary. (See fig. 1 in Bédard et al. 1995a for location of the colonies referred to in the text.) The waters are brackish (ca. 1–2 ‰) in the upper part of the estuary near the Cap Brûlé colony but almost as salty as ocean water (ca. 33 ‰) at the lower end near the Raguenau cluster. A complete census made in 1987 indicated the presence of 14,662 nests. For administrative reasons, however, the program was deferred until 1989. Therefore, the reference population (1989) was calculated in part from the 1987 data and from fragmentary censuses of a subset of islands in 1988.

[1] Culling here refers to the removal of a predetermined number of animals to achieve a stated population management goal.

The 1989 population was estimated at 17,361 breeding pairs, of which 7,544 nested in trees and 9,817 nested on the ground. Complete censuses were undertaken in 1991 and 1993.

All colonies were visited during the program with two exceptions: Caribou Cape (a 75-m vertical bluff) and Laval Island along the north shore. These were censused directly from a helicopter or from aerial photos. When some owners revoked permission to access their island as the program evolved, the percentage of ground nests accessible for spraying dropped below the 90 percent of all nests judged ideal in modeling (Bédard et al. 1995a).

Methods

Methods have been described elsewhere (Bédard et al. 1995a, 1995b), and only a brief summary follows. In arboreal colonies, adult birds perched on or near the nest were culled using a .22-caliber rifle fitted with a scope. Depending upon the terrain, nest density, and behavior of the birds, the operator could shoot as many as 100 (75 birds/hour) from a single position before moving on as the area became devoid of birds.

In colonies where forest cover was sparse and/or damaged by prolonged cormorant occupation, the operator could not hide as easily, and lower density of nesters and wariness of the birds reduced success considerably. This situation prevented us from applying a rigorously proportional culling scheme: on some islands, it was impossible to reach the allocated goal whereas relative tameness of the birds on others allowed us to exceed it. Culling occurred during late April and early May of each year prior to hatch. In 1991, however, tree nests were censused before starting the cull and after the number of breeding pairs had peaked (around May 20). Therefore, hatching had begun in a large proportion of the nests when culling began in that year.

Tree nests were censused by using systematic ground counts and the presence or absence of whitewash to determine whether or not a nest was occupied.

Several visits to a given colony were needed to remove adult birds. On remote islands, such as the Raguenau and the Kamouraska clusters, complex logistics and disturbance to other species restricted the duration of visits to 2 or 4 days, and several concentrated episodes of shooting lasted 2–4 hours. On more accessible islands, such as Gros Pot and Les Pèlerins, as many as 14 visits/year varying in length between 1 and 4 hours were needed to reach the desired goal. Carcasses were buried onsite with the exception of a random sample of 1,137 that were set aside for complete necropsies, the results of which have been reported elsewhere (Bédard et al. 1995b).

Egg spraying was carried out with a backpack sprayer using DAEDOL 55 USP®, a nontoxic oil found to have 100-percent efficiency in earlier tests (Bédard 1988, Blokpoel and Hamilton 1989). The eggs were sprayed only on the top side as they lay in the nest. Spraying was undertaken in every year of the program along with a complete census of the apparently occupied nests. On islands harboring ground-nesting cormorants only, nest tallies were made and eggs were sprayed every year in the third week of May. On islands with mixed sea bird colonies where protection of sensitive species such as razorbilled auks *(Alca torda),* common eiders, and BCNH's was deemed essential, the operations were deferred until the first week of June, when all aquatic bird species present were censused on a single visit, thus minimizing disturbance. Therefore, there could be as many as 10 days between censusing the first and the last cormorant colony in any given year.

To detect the possible spread of the cormorants in response to culling, every island in the estuary offering potential habitat for the bird was overflown or visited yearly to detect possible shifts in colony location or the invasion of new nesting sites.

Results

The number of breeding birds killed in each of the first 4 years of the program is given in table 1. No adult birds were shot in 1993 because the late-May census for that year revealed that the overall goal of 10,000 nesting pairs had already been reached. At that time, the estimated number of breeding adults was 9,561 pairs (see the Discussion section). In total, 7,917 adult birds were killed instead of the forecast 10,000 (at the rate of 2,000 per year). The sex ratio among the culled birds was strongly male dominated (203:100), which revealed a much greater attentiveness, a much greater vulnerability to culling in this sex or both (see Bédard et al. 1995b).

The number of clutches sprayed with mineral oil in each year of the program is given in table 2. In all, 25,095 nests were sprayed, the average being 5,019 ± 218 SE per year, which is somewhat below the initial goal of 7,000/per year deemed necessary to lower recruitment.

The rapid decrease in the number of nests in arboreal colonies underscores the efficiency of the program. The model predicted 6,014 tree-breeding pairs in 1991 and 4,845 in 1993 in the culled population, whereas measured values stood rather at 3,856 and 2,555, respectively (table 3).

Table 2. Number of double-crested cormorant nests sprayed with mineral oil during the 5-year program

Island	1989	1990	1991	1992	1993	Total/ island
Cap Brûlé	90	132	116	119	74	531
Pilier-de-Bois	1,117	1,506	1,191	980	674	5,468
Gros Pèlerin[1]	0	0	0	0	335	335
Île aux Fraises	0	0	0	0	2	2
Île Blanche	0	0	0	0	9	9
Île Blanche (récif)	0	94	39	17	10	160
Île aux Pommes	776	831	374	755	536	3,272
Islet aux Alouettes	757	622	763	834	430	3,406
Razade-sud-ouest	283	602	472	384	485	2,226
Razade-nord-est	236	75	110	0	83	504
Bicquette-Récif Ouest	485	0	0	0	84	569
Bicquette-Récif Est	0	0	0	0	100	100
Île du Bic-Récif Est	312	142	53	7	0	514
Îlot du Grand Mitis	138	165	150	150	163	766
Les Boules	292	443	141	318	251	1445
Récif Boulay (Raguenau)	0	0	103	273	101	477
La Boule (Raguenau)[1]	0	0	517	359	269	1,145
Petite Boule (Raguenau)[1]	0	0	0	0	502	502
La Mine (Raguenau)[1]	850	1,082	470	504	758	3,664
Total	5,336	5,694	4,499	4,700	4,866	25,905

[1] Colonies in which both culling and spraying took place.

Table 1. Number of adult double-crested cormorants culled on their nests during each year of the 5-year program

Island (archipelago)	1989	1990	1991	1992	1993	Total/ island
Brûlée (Kamouraska)	0	516	141	434	0	1,091
Grande (Kamouraska)	128	0	0	0	0	128
Petit Pèlerin	485	365	314	439	0	1,603
Gros Pèlerin	0	0	0	83	0	83
Gros Pot à l'Eau-de-Vie	1,380	1,197	1,050	808	0	4,435
La Boule (Raguenau)	0	0	157	23	0	180
Petite Boule (Raguenau)	0	0	2	188	0	190
La Mine (Raguenau)	0	0	124	83	0	207
Total	1,993	2,078	1,788	2,058	0	7,917

Table 3. Number (and percent) of double-crested cormorant nests in the St. Lawrence River estuary according to the nesting situation (tree *v.* ground)

	[1]1987	1989	1991	1993
Tree nests	6,802 (46)	7,544 (43)	3,856 (31)	2,555 (27)
Ground nests	7,860 (54)	9,817 (57)	8,412 (69)	7,006 (73)
Total	14,662	17,361	12,268	9,561

[1] The 1987 figures are presented as a reference only. The culling program was initiated after the 1989 census and ended in 1992.

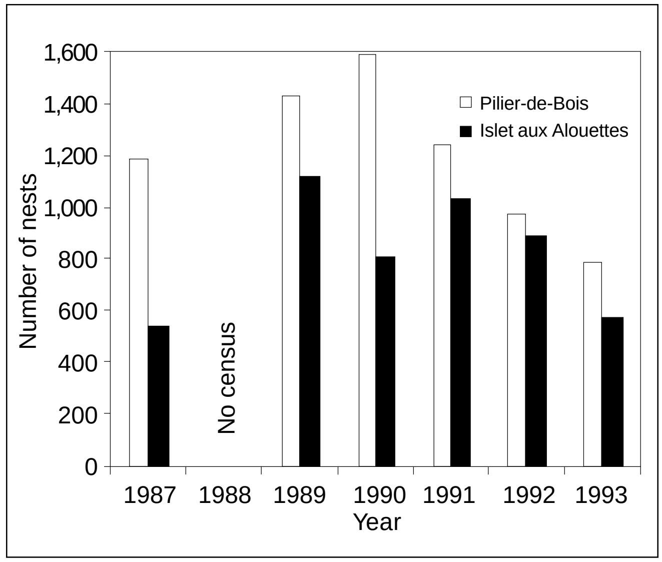

Figure 1—Number of ground nests in two double-crested cormorant colonies in the St. Lawrence River estuary, 1987–93. Beginning in 1989, all nests were sprayed with mineral oil.

The effects of spraying clutches in slowing down recruitment followed predictions. A 2-year inertia in the system was expected because, presumably, two yearly cohorts of subadults were waiting to breed as treatment began. It was only after these two cohorts had joined the ranks of the breeders that the first signs of depressed recruitment would show up. This pattern of change in two selected colonies is shown in figure 1. Barring an unexplained dip in numbers on Islet aux Alouettes in 1990, the pattern showed the predicted hump (in 1989 and 1990) as the subadults entered the breeding stock; the absence of recruits resulting from the first egg spraying of 1989 began to be seen in 1991 and continued into 1993.

The relative abundance of tree *v.* ground nesters shifted markedly. In 1989, 43 percent of all nests were in trees as against only 27 percent in 1993 (table 3). The drop in numbers between 1989 and 1993 was very dramatic in arboreal colonies, and the overall number of pairs dropped from 7,544 to 2,555, which represents a 66 percent decline (table 3). In ground-nest colonies, the drop from 9,817 to 7,006 corresponded to a 29- percent decline in the number of breeding pairs.

Because we flew over every single island in the estuary during the annual census, we are certain that only 1 new colony was established during those years: a small 75-nest colony appeared on the eastern tip of Lièvres Island in May 1993, most likely founded by birds under strong culling pressure on neighboring Gros Pot Island. Minor shifts did occur among islands within the same archipelago (in particular the Raguenau cluster). However, similar movements occur all the time, even in undisturbed conditions, and we do not believe they were induced by the program.

Discussion

We estimated the total estuarine population at 33,518 birds in June 1993. According to the model (Bédard et al.1995a), this total should have been made up of 19,122 breeding adults (or, from table 3, 9,561 breeding pairs) and 14,396 subadults (not counting juveniles in the nests at that time). This is only 35 percent of the predicted estuarine population (94,760 birds in all or 53,958 adults and 40,802 subadults) had there been no program. See table 1 in Bédard et al. (1995a) and explanations therein for the way to predict the proportion and numbers of both categories.

The census results are judged reliable overall because we had several opportunities to validate tallies in a subset of colonies visited frequently for other purposes during the ongoing program. The Laval Island colony, however, was fogbound on the day of the 1993 census. Therefore, the population was estimated at 303 pairs (tree nests only) based on the latest available census figure (247 nests for 1991), corrected by the overall population growth factor of 10.8 percent. Ground transects in this colony in 1995, 2 years after completion of the culling program, led, however, to an estimate of 1,590 ± 225 nests (Bédard and Nadeau 1995 unpubl.). This disparity raises suspicion about the 1993 estimate: the population on this island in 1993 could have been higher than indicated by 300 or 400 nests. The disparity does not affect the overall conclusions, however. The 10- to 12-day spread required for censusing all the estuarine colonies is not seen as a cause of distortion of the census results either.

Although no birds were marked, we believe that the two population segments (tree- and ground-nesting) remained independent thoughout. Until proven otherwise, they will be viewed as separate components of the same population particularly for such a large geographic area as the St. Lawrence estuary. Most likely, ground-nesting birds remain ground nesters throughout their reproductive life, and tree-nesting ones do likewise. This conclusion might have relevance in cases when control is desirable in a population split in two such divisions: population reduction could be restricted to the segment causing concern. In our case, culling was restricted to tree-nesting birds because egg spraying simply cannot be carried out in shaky, half-rotten trees. Furthermore, it is impossible to shoot ground-nesting cormorants because after the first few shots, the wary birds will remain at sea until departure of the hunter.

In some respects, the culling program has been too effective. As explained earlier, conformity to the model has been adequate in the case of the ground-nesting set, but the decline in numbers in tree-nesting birds was steeper than predicted. There are several possible explanations for this situation.

In the original simulation, age at first breeding was set at 3 years as suggested by the data available. This value generated a growth pattern closely mimicking that observed between 1979 and 1989 (Bédard et al. 1995a). If age at first breeding is actually 4 years instead of 3 (and the number of fledglings is adjusted accordingly), the population trends can still be mimicked exactly by the model. However, in these circumstances, the removal of 1,979 ± 132 SE birds/year in the first 4 years of the program would have precipitated the decline in numbers. This issue cannot be resolved because empirical figures on age at first breeding are lacking.

Many colonies were never visited after the May–June census and culling operations, and many unrecorded events could have taken place there in the last part of the breeding season. For instance, outbreaks of bacterial or viral diseases could have decimated some of the colonies. Newcastle disease had been reported previously in some colonies (Cleary 1977 unpubl.) and is suspected of having generated some losses in the Gros Pot colony in 1990 and 1991 as revealed by the presence of several fledglings displaying the warped-wing syndrome, a diagnostic condition of this viral disease. We also know that the owner of 1 large colony destroyed some 500 nests in 1 year of the program. This was done without a permit and despite earlier agreement with the managers of the culling program. The real impact of such factors cannot be assessed.

A major cause of the steep drop in numbers could be the pronounced difference in vulnerability of the sexes to culling. Because 203 males were killed for every 100 females, it follows that breeding was being halted in a larger proportion of nests than anticipated at the start. As far as is known, a lone partner cannot successfully hatch eggs let alone feed nestlings until fledging. Killing just one member of the pair in each nest would be the ideal solution; it is, however, unrealistic, for it is impossible to identify the members of any given pair and impossible to identify those nests in which one adult bird has already been removed (either on that day or during an earlier culling episode). For instance, on Gros Pot island, we removed 4,435 adult birds (2,971 males and 1,464 females at the established ratio) during the 4-year program. In theory, breeding could have been disrupted in 4,435 nests had all adults been shot in different nests. If we assume that half the females culled were culled along with their mates, we disrupted breeding in only 3,703 nests. Whatever the real proportion is, the cull released from breeding duties a large number of lone birds (mostly females). The presence of large numbers of loafing birds around treated colonies was seen as indirect evidence for this. On Gros Pot à l'Eau-de-Vie island, for instance, where we culled as many as 1,380 individuals in a single month, some 400–500 individuals could be seen loafing around during the peak of the culling activity. A proportion of these could have been females that abandoned their nests because their male partners had been killed.

Because DCCO's are likely faithful to their nesting colony, this unbalance in sex ratio will persist in subsequent years and will prevent a sizable fraction of the female population from finding a mate. That, in turn, will further precipitate the downfall of the colony. This effect probably will wane a few years following the end of culling.

Cost Effectiveness

Running the program required 5 weeks of work per year for a crew of three. Itemizing the cost is difficult, but the census (helicopter) flight, imposed by the huge size of the estuary, required $6,000/year. Accessing some 15–20 colonies by boat cost another $5,000/year. Salaries (ca. $8,000/year), field expenses (supplies for necropsies, mineral oil, etc.), data analysis, report writing, and administrative costs brought the total to $38,000/year (excluding the 1987 pilot study and census). This is a very rough estimate, but we calculate that culling an adult DCCO cost about $10, whereas spraying a nest with mineral oil cost about $3. These figures are site specific and cannot be generalized. Cost could be considerably lower for a smaller geographic area and/or a smaller number of colonies.

Public Perception of the Program

In the St. Lawrence River estuary, DCCO's forage on abundant species such as sand lance *(Ammodytes* sp.), capelin *(Mallotus villosus),* and nongame inshore species (e.g., *Pholis* sp. and *Myoxocephalus)* (Rail et al. 1996). Lobbyists from the sport and commercial fishery sectors were not instrumental in pressuring to cull the population. This decision was made mostly to protect unique insular plant communities whose destruction was affecting colonies of great blue herons *(Ardea herodias),* BCNH's, and common eiders. Only 20 of the 60-odd islands in the estuary are wooded, and several had already been severely damaged by DCCO's in the period 1970–87. Destruction of forest cover would not be a problem along the Québec lower north shore, for instance, or along the Nova Scotia shores described by Milton et al. (1995) because, in both regions, hundreds of islands are available to nesting birds, and, in the worst circumstances, cormorants would occupy only a very small fraction of them.

Preparing Public Response

A thorough pilot study was carried out to test field techniques and to model the consequences of various culling and recruitment-blocking strategies (Bédard 1988). The culling was contracted out to a regionally well-established conservation organization and conducted under close biological supervision. Interim reports were required and produced, and the program was reviewed every fall. Accurate tallies of the number of birds killed and the number of nests treated, as well as a report of expenditures were available at all times. Before the program was publicly announced, representatives from key birding groups and regional conservation organizations were taken into the field and shown habitat damage that the cull was designed to halt. Despite these measures, press coverage was acerbic and negative. Anyone wishing to launch a similar program should pay the utmost attention to preparing public opinion well ahead of time. Some aspects of the cull, such as killing adult birds tending nestlings, should be avoided at all costs (in our case, this was perceived as unavoidable in 1 year).

Followup Program

The numerous causes of the current population explosion in DCCO's in the Great Lakes have been well reviewed by Weseloh et al. (1995). Several of these apply to the St. Lawrence River population as well. Because our culling program addressed none of the factors that provoked this growth, we expect the population to bounce back around 1996–98. Unfortunately, the estuarine population has not been censused since 1993, and followup measures to halt further growth are not being planned at the moment. Nevertheless, we believe that inexpensive methods could be applied in strategic ways to maintain the population at the desired level. Egg spraying in the largest colonies (such as Les Piliers, Île aux Pommes, and a few others) could be continued at a fairly low cost. Carefully timed visits to tree-nesting colonies could also be used to restrict growth. Dislodging nests using long poles after the incubation period is half over efficiently disrupts the breeding cycle and leads to breeding failure and site abandonment. In some instances, repeated disturbance will enhance egg and nestling predation by gulls, which are almost always present in cormorant colonies. At the very least, the government should census DCCO populations every 3 or 4 years to detect any recurrence of the problems resulting from a renewed demographic spread of this species.

General Thoughts on Culling

Culling wild animal populations is a sensitive issue, and the problem threatens to become more common as people disrupt nearly every ecosystem on this planet. For instance, the collapse of the ground fisheries in the North Atlantic and Gulf of St. Lawrence has released huge stocks of forage fish species (Rail et al. 1996), which, in turn could have helped sustain the spectacular increase in eastern Canadian populations of many sea birds, including DCCO's. To this day, few populations of wild animals have been the subject of such extensive culls (but see Duncan 1978).

Many problems of overabundant wildlife are lurking on the horizon, however (Garrott et al. 1993), and a philosophical aspect of the question is particularly nagging. Should wildlife biologists use the same knowledge and principles that they use to restore endangered species to control common ones whenever they are perceived to be causing damage to a given ecosystem? The problem of deciding when an animal is sufficiently abundant to cause damage is particularly difficult in itself. However, if we can trust field biologists to determine when a population is in jeopardy, why is it that we cannot trust them to decide when that same species is placing its own ecosystem at risk? A nice illustration of this situation presently in the making is the case of white geese in North America (Batt 1997), which are destroying their nesting habitat. A cull of adult birds could be a part of the answer, but every single technique proposed so far to reduce the flock has been highly controversial (Johnson 1997).

In the case of the cormorant, the possibility of an open hunting season has been proposed in some parts of the range. We personally believe that it would be a mistake to turn into game a species that has been excluded from the hunter's bag for 80 years. Cormorants do not inspire respect among waterfowl hunters, and whether they would be used as real game is doubtful. Furthermore, our work has shown how easy it is to decimate a cormorant population. Reproductive parameters in cormorants are very similar to those in sea ducks in general (deferred maturity, small clutch size, low recruitment of young birds into breeding population). This group is extremely vulnerable to even a slight increase in adult mortality such as that induced by hunting (Goudie et al. 1994). Entrusting the management of the cull to wildlife agencies rather than to hunters offers another benefit in that it generates badly needed scientific information on the animal, which is a major bonus when compared with the alternative. This approach also offers greater flexibility as exemplified by our decision to interrupt the cull on very short notice when we realized that our population objective had been reached.

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